Geomorphology of a Coastal Desert:
The Namib, South West Africa/Namibia

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ABSTRACT


The geomorphological evolution of the coastal desert of Namibia dates essentially from the Jurassic-Cretaceous monoclinal folding of the southern African continental margin in response to the plate-tectonic fragmentation of Gondwanaland. This study supports KING's (1962) regional observation that following this event, the dominant denudational impact on the landscape has been pediplanation with associated cycles of river incision, scarp retreat and pedimentation. In addition, impacts on the local geomorphology stem from the influence of an arid climate in combination with three quasi-independent processes: (1) a differential response to mechanical weathering governed by lithology, (2) a complex interplay between fluvial, marine and eolian processes, and (3) the further influence of changing sea levels on this tri-process system. Prominent erosional and aggradational landforms are noted. In particular, the sand dunes that extend over a vast area (35,000 km²) between Luderitz Bay and Walvis Bay are classified on the basis of satellite image interpretation. This great expanse of dunes, which has truncated rivers and blanketed rich deposits of alluvial diamonds, continues to grow. In its development there has been a dynamic interplay of eolian and fluvial processes that controls its spread. Recommendations are made that would help preserve this unique coastal environment and the diverse ecology that it supports. Finally, it is suggested that an extension of the research described may have applications that help define the regional distribution of diamonds in the area.

ADDITIONAL INDEX WORDS: Alluvial diamonds, coastal desert, fluvial processes, Namibia, ocean current; pediplanation, sea-level change, storm wave, wind.

INTRODUCTION

"Difficult of approach, presenting a forbidding aspect from the sea, and mostly enshrouded in dense fog, (this coast) had received little attention until 1908, when diamonds were discovered near Luderitzbucht. Since then, diamonds have been proved to occur along the coast at intervals for nearly 600 miles and it is thus entitled to be regarded as one of the most remarkable stretches of coast-line in the world." P.A. Wagner, 1927.

The relative stability of this part of the African plate combined with a long-standing arid climate, preserve landforms that are extremely old, and establish a geomorphological pattern that is more intimately tied to underlying geology and geological processes than in most other places. Geomorphological studies, therefore, play a vital role in reconstructing the geological history of the area. This, in turn, has immediate application to the distribution of alluvial minerals.

Exploration and mining offshore (Figure 1), along the beaches (Figure 2), and on raised marine-terrace deposits onshore (Figure 3) demonstrate the prolific availability of diamonds on the Namibian coastline. Yet its inhospitable nature, great size and relatively complex geological history, leave the precise source and the subsequent distribution of many potentially workable deposits inconclusively established.

Much of the research undertaken in the area by the senior author and others was conducted for the diamond industry and is proprietary. Reviews of geology in relation to the distribution of diamonds are presented by DE BEERS (1976), KEYSER (1972), and WAGNER and MERENSKY (1928).
Outstanding work of geomorphological significance in the area includes McKee (1979; 1982), Seely and Sandelowsky (1974), Goudrie (1972), King (1962), and Logan (1960). The present research was reconnaissance in nature and observations are broadly based. The study addresses in particular the geomorphological controls on the vast Namib erg, referred to as the Great Sand Sea, and the areas immediately adjacent to it. It was the objective of the authors to: (1) present a preliminary framework of up-dated thinking that sets the stage for more detailed work, and (2) identify the potential for follow-up research, particularly in terms of practical applications. In addition to diamond prospecting, applications include petroleum exploration. It is considered, for example, that the initial slow spreading of the African and South American plates during a Red Sea stage in the opening of the South Atlantic, provided at times an anaerobic environment particularly conducive to the formation of hydrocarbons. Further applications relate to a better assessment of environmental impacts associated with future mining, and such engineering-geological projects as harbor extensions, ocean outfalls, bridges and dams. Finally, extensive potential benefits to wildlife may be derived from more detailed hydrogeological studies, especially in areas such as Etosha Pan.

METHODS

In remote, arid areas such as Namibia (Figure 4), the satellite image is a particularly cost-effective way of interpreting regional geomorphological trends. In the present study, the image provided a perspective that was not readily discernable in the field. For example, an investigator in the field is dwarfed by the complex linear dune ridges that are up to 300 m high (Figure 5), a circumstance which no doubt led Logan (1960) to describe their pattern as “chaotic and disorderly.” Satellite image interpretation suggests, on the contrary, that although the individual dune forms do tend to be complex, their pattern of distribution is quite systematic (e.g. Figure 5).
Image interpretation was supplemented by photogeological studies of selected areas, using aerial photographs (e.g. Figure 6) made available by the Director of Surveys and Mapping, Cape Town, Republic of South Africa. The authors checked their interpretations in the field, compiled further data, and undertook limited laboratory studies.

The text of the paper is based in part on the personal observations of the authors and research assistants, and in part on published information. A review of the established geological history of the area provides the necessary background for new observations. The pediplation cycle, well known to geomorphologists, is briefly explained for the benefit of the non-geomorphological reader because its comprehension is fundamental to an evaluation of the present study.

**PALEOCLIMATIC REGIME**

The aridity of the area is a function of the cold Benguela Current which, with associated cold-water upwelling along the coast, severely limits sea-surface evaporation. The authors concur with King (1962) that the origin of the Benguela Current cannot predate the Late Oligocene/Early Miocene formation of the Circum-Antarctic Current, following the separation of Australia and the South Tasman Rise from Antarctica. However, from the evidence of a network of fossil drainage courses and of warm-water molluscs found on marine terraces (Keyser, 1972; SACS, 1980) it is probable that the present arid conditions were interrupted from time to time during the Quaternary by humid intervals.

The climatic characteristics of the coastal desert are not confined to Namibia, extending northwards into Angola and southward into the Republic of South Africa (Logan, 1960). However, this study was confined to Namibia where the desert is bounded on the west by the Atlantic Ocean and on the east by the Great Escarpment. The escarpment generally parallels the 100-mm rainfall isohyet (McKee, 1982) and the desert receives an average of less than 100 mm of rain a year, the precipitation being highly irregular. For example, while Swakopmund (Figure 4) showed a 20-year mean of less than 16 mm and parts of the Namib have experienced 15 years without rain (King, 1951), other areas show the effects of torrential sheet and channel floods. As will be discussed later, water is an important process in shaping this desert landscape.

Within several kilometers of the shoreline, the moisture associated with frequent fogs amounts to as much as 25 mm of annual equivalent rainfall (Royal Navy and South African Air Force, 1944). Along the coast this augments the normal precipitation, and helps sustain a complicated chain of organisms.

The regional atmospheric circulation is controlled by three semistable high-pressure areas, the South Atlantic high (centered at approximately Latitude 30° South, Longitude 10° West) the Indian Ocean high (Latitude 30° South, Longitude 65° East) and a high pressure area over the interior of southern Africa. Strong southwesterly winds prevail along the coast and, in association with the considerable South Atlantic fetch, generate characteristically heavy seas and lead to a strong northerly longshore current (and associated drift). Steady-state surf action punctuated by storm conditions play a dominant role in shaping the geomorphology of the coastline. During a storm in February, 1965, for example, wind-generated waves on the order of 30 m high were observed by the senior author. These waves exhibited sufficient energy to beach the offshore mining unit Colpontoon (Figure 7) from a position beyond the surf zone where it was secured by six deep-sea anchors, and to capsize, sink,
Figure 5. Satellite image (left) and interpretation (right) showing dune patterns in the northern part of the Great Sand Sea inland from Walvis Bay.
and break up, overnight, an ocean-going tug attempting to assist it. Storm waves and associated affects (e.g. wave-induced liquefaction) were observed, furthermore, to play a dominant role in reworking near-shore sediments.

In addition to generating extreme wave-loading conditions on the shoreline, southwesterly winds play an important role also in transporting beach sand inland, and thus in establishing and contributing to the patterns of dune formation (e.g. Figure 5).

Figure 6. Aerial photograph showing complex linear dunes terminated by the Kuiseb River.

Inland of the coastline, the force of the southwesterly winds diminishes rapidly and the wind regime is complicated by sometimes-strong “berg” winds that are predominantly easterly, but which in turn are locally deflected by thermal anomalies, and the physical features of the valleys, stream beds, inselbergs and sand dunes.

**GEOMORPHOLOGY**

**Pediplanation Cycle**

As implied, the geomorphological evolution of this old and generally uplifted region may be best described in terms of the cyclic denudational land surfaces outlined by King (1962). The model is based on the pediplanation cycle under which the general order of geomorphological processes is river incision, scarp retreat and pedimentation. The gently-sloping pediment grows headward, as the steeper slopes above it retreat by mass wasting. In combination with the inevitable main scarp above a developing pediment, isolated landscape highs tend to persist in response to drainage-erosion anomalies and/or differential lithologic resistance to erosion, but with time these bedrock inselbergs are also eventually bevelled.

Thus, the features of a characteristic land surface, such as the Gondwana plateau (Figure 8), persist
Figure 8. Cyclic denudational landsurfaces of Namibia (after KING, 1962).

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The Great Escarpment

The Great Escarpment represents the dissected margin of the Gondwana and African landsurfaces (Figure 8), the oldest landsurfaces recognized by KING (1962). As shown in Figure 4, this high ground commonly forms a drainage divide, the western slopes of which constitute catchment areas for flood-flow rivers that drain across the desert, directly to the ocean. The eastern slopes provide a source for rivers such as the Fish (Figure 9), which flow predominantly southwards to become the tributaries of the Orange River, or northwards and eastwards to drain into the huge, inland depression deltas of the Kalahari. These, the Okavango Delta and the Makgadikgadi Pans in Botswana, and the Etosha Pan in Namibia, provide unique opportunities for extensive hydrogeological research. As suggested in the introduction, such studies would be of enormous benefit to the wildlife management of the subcontinent.

The dynamic nature of the Great Escarpment (and similar features along the margins of South America, India, and Australia) was treated in a classical monograph by JESSEN (1943) under the name of "Grosse Randstufen." Their vertical differential motions were difficult to explain until the discovery of plate tectonics. This is a "passive" or rifted (Red-Sea type) margin and its epirogeny is understandable in terms of heat flow, crustal cooiling, and eustatic history (FAIRBRIDGE, 1968; 1982).

The initial rifting of this sector occurred in Paleozoic times, sedimentation occurring in an aulacogen-type trough. During the Permo-Carboniferous glaciation there were fjords debouching ice into the trough (MARTIN, 1975). Simultaneously, a comparable situation existed along the western border of Australia where a rift was also associated with fjords (FINKL and FAIRBRIDGE, 1979). The superposed fluvio-glacial drainage system in both regions is thus more than 300 million years old.

The Namib Platform

The Namib Platform extends seaward from the base of the Escarpment. This Late Cenozoic landscape which slopes to the west at less than 1 degree supports the desert landscape.

The most prominent landform features of the desert are the high (up to 300 m) sand dunes. These begin just north of the Orange River, but are not well organized until Luderitz Bay, where they expand into the Great Sand Sea, some 35,000 square kilometers in extent. This vast dune area is terminated, in effect, by the Kuiseb River (Figure 5). However, a narrow section of dunes has broken across the mouth of the Kuiseb and...
spread north to the Swakop River. North of Swakopmund a further narrow (20 km) belt of dunes stretches north of the Huab River, widening just south of the Kunene River (Figure 4).

The eolian, fluvial and marine processes that control the distribution and patterns of dunes are discussed in more detail, in subsections that follow.

Those areas of the Namib Platform not covered by sand dunes show a variety of landforms. Over the northern part, exposed, roughly bevelled bedrock predominates. Erosional dissection at the present time is due to mechanical rather than chemical weathering and landform patterns are controlled both by lithology and structure. Farther south, approaching the Swakop and Kuiseb Rivers (Figure 5), bedrock tends to be masked by sheet and streak (windblown) sands, fluvial terrace deposits, and thin, but widespread sands and gravels on the pediments surrounding inselbergs.

Away from the Escarpment, the inselbergs that protrude like islands within a sea of sediment, are generally comprised of intrusive granites. However, adjacent to the Escarpment inselbergs exist as outliers, and consist of a variety of the more resistant rocks (e.g. quartzites) of the Precambrian Damara Sequence that underlies much of the area.

Landforms associated with intrusive rocks exist commonly as both broad, exfoliating domes (Figure 10), and joint and weathering-controlled “boulder kopjes” (Figure 11). Less-common diabase dike swarms are seen as resistant, parallel ridges that crop out through desert-plain sediments (Figure 12) and exert an important local control on surface and ground-water flow.

Other than inselbergs, the most common landforms
adjacent to the Escarpment are extensive fluvial terrace deposits. Three separate terrace surfaces were identified over the large area extending inland of Luderitz Bay to north of the Kuiseb River. These terraces from the oldest and highest down, are referred to, provisionally, as the A, B and C surfaces.

Of the three, the A-terrace (Figure 13) is the most prominent. This surface is characterized by an abundance of rounded quartz pebbles that have weathered out of conglomeratic parts of the calcrete that constitutes the terrace. Excellent exposures of terrace deposits are found in the Kuiseb Canyons.

Above the high A-terrace, a pre-A surface exists on a red sand/sandstone which may represent a residual weathering regolith. The beds probably constitute the Tsondab Sandstone Formation (Besler and Marker, 1979). Red sands have been reworked and show eolian cross bedding in places. These sands are apparently the main source of the red dunes that dominate the inland portion of the Great Sand Sea.

**THE COASTAL STRIP**

The zone referred to as the Coastal Strip is the narrow, elongated area immediately adjacent to the ocean (and extending the full length of Namibia). Consisting of the Congo Landsurface (Figure 8), it averages between 10 and 20 km in width, but extends inland locally in response to river incision. The Fish River Canyon (Figure 9) provides an excellent example of this incision. The predominant landforms of the Coastal Strip are sand dunes, large northerly-extending sand spits (e.g. Figure 5, Walvis Bay), raised (including buried) marine terrace and terrace deposits (Figure 3), sandy beaches, and exposed bedrock headlands.

The Coastal Strip has been significantly influenced by Pleistocene and earlier sea-level changes. Between Oranjemund and Chameis Bay as many as six marine transgressions have been identified (e.g. SACs, 1980). In the vicinity of Chameis Bay where the senior author undertook both prospecting and offshore mining, drowned terraces exist, but are less readily delineated.

Diamondiferous marine gravels associated with raised beaches are found to elevations of approximately 85 m MSL (De Beer, 1976). The preferential concentration of diamonds in the vicinity of fossil river valleys and estuaries (De Beer, 1976; Keyser, 1972; and personal observation) is considered to be associated with a second-generation reworking of diamond-bearing terrace deposits by fluvial action (incision). Subsequent (and ongoing) marine action has further reworked and concentrated offshore diamonds, accounting for the higher proportion of stones of gem-quality offshore, as opposed to on-land deposits. The fact that most of the raised beach deposits, and much of the fossil drainage system has been covered by wind-blown sand, makes prospecting on the Coastal Strip a difficult task.

**Geomorphological Zones**

Within Namibia, the coastal desert is divided into three geomorphological zones: (1) the Southern Namib which stretches north of the Orange River to Luderitz Bay, (2) the Great Sand Sea which although effectively bounded by the Kuiseb River, extends in a narrow strip immediately adjacent to the coast, as far north as the Swakop River (Figure 5), and (3) the Skeleton Coast which reaches north to the Kunene River on the Namibian border (Figure 4).

The Southern Namib shows bedrock and sand almost equally exposed at the surface.

The Skeleton Coast area is characterized by exposed bedrock, the relatively straight lower reaches of intermittent streams, and coastal sand dunes north of the Huab River. The landform pattern is most strikingly apparent on satellite imagery and is controlled by a fold belt of exposed Precambrian rocks, aligned more or less parallel to the coastline. This is considered to be a remnant of plate-tectonic compression associated with the Late-Paleozoic assembly of Pangaea. As similarly observed in the Cape Fold Belt, this landform pattern and associated structural style have been distorted by the subsequent breakup of the supercontinent.

The Great Sand Sea consists, as implied, essentially of sand dunes. These were classified on the basis of satellite image and aerial-photograph interpretation, and are discussed in the section which follows.
Geomorphological Processes

Eolian

Wind is a most important geomorphological agent. (1) with respect to its influence in generating wave and wave-associated loading on the shoreline and (2), in transporting sand inland from the beach, and controlling the patterns of sand dunes.

The strong prevailing southwest winds blow with greatest intensity during the southern spring and summer. The annual sand rose (after BREED et al., 1979) plotted in the vicinity of Walvis Bay (Figure 5) shows a typical resultant sand drift to the northeast.

Based on satellite image interpretation, it is suggested that where sand is abundant, the response to this narrow unimodal wind regime is a pattern of largely transverse dunes. The 10 km by 250 km band of coastal transverse dunes shown in Figures 5 and 14 illustrates this point. Where the sand supply is less, as in the coastal strip between the Kuiseb River and the Swakop River (Figure 5), barchan (Figure 18) and barchanoid ridge dunes tend to predominate.

Inland of the coast, the intensity of the wind diminishes rapidly and eventually gives way to hot prevailing easterly winds referred to as “berg” (meaning “mountain”) winds. Sand rose Number 2 in Figure 5 shows the resultant sand drift at a distance of about 70 km from the coast, for the month of highest drift potential (July). As cautioned by BREED et al. (1979), this sand rose represents only one month, so it is not directly comparable with the annual sand rose shown near Walvis Bay (Figure 5).

Within the transitional area occupied by the central portion of the Great Sand Sea, the combined influence of southwesterly and easterly winds contributes to a bimodal wind regime that results in a pattern of linear dunes. Typical of the north-central portion of the Great Sand Sea are complex linear dunes of coalescing ridges of star dunes superimposed on the crests of linear dunes (Figure 6), while simple linear dunes characterize the southern interior portion (Figure 14).

In the vicinity of shallow or dry lakes referred to as “vleie” (singular: “vlei”), such as Sossos Vlei (Figures 4 and 15), contrasting topography imposes an additional complicating control on the wind regime, and more complex dune types result. These are typified by large star dunes (Figure 16) which in the vicinity of Sossos Vlei coalesce to form high, subparallel ridges (Figure 15). Over much of Tsondab Vlei (Figure 5) the dune pattern is too disrupted to classify.

Star dunes have formed over the extreme western portion of the Great Sand Sea. Their formation is in response to a weak bimodal wind pattern complicated by inselberg-dominated topography.

Fluvial

A simplified pattern of surface-water drainage is shown in Figure 4. Three categories of streams are distinguished, major, intermediate and minor.

As shown, the Orange River which drains much of the interior of South Africa is the only major river in the area. In spite of its large catchment area, its flow, although perennial, is highly variable. Its geomorphic importance related primarily to its sediment carrying capability. It about 45 million metric tons per year (KING, 1951).

With the exception of the Kunene River on the northern border, all other streams have their sources within Namibia and are strictly ephemeral, existing as dry “omirimbi” most of the time, although subject to periodic flash flooding. For example, in the flood of 1934, the Swakop River (Figure 4), a minor stream, which during normal times flows to the sea for only short periods every 2 to 3 years, transported approximately 35 million m$^3$ of sediment, advancing the coastline more than 1 km into the ocean in the vicinity of Swakopmund (STENGEL, 1964). This sand was subsequently removed by coastal erosion processes.

The influence of running water on the landscape of the coastal desert, although occurring over periods of only hours or a few days every several years is a most important one. The courses of rivers such as the Kuiseb and Fish, for example, are well incised into bedrock over considerable portions of their reaches. The Fish River Canyon (Figure 9) up to 900 m deep, extends over a distance of about 65 km. Such deep erosion, of course, does not necessarily reflect the present climate.

All of the rivers in Namibia are infrequent, even during periods of exceptional precipitation. Linear ground-water mounding beneath usually dry stream beds is an essential factor in sustaining vegetation there which supports a variety of insect, mammal, reptile, and bird life. In addition, diabase dikes (Figure 12) and/or lenses of relatively impermeable materials refract ground-water flow nearer the surface and occasionally create waterholes, or oases that support such large mammals as deer and elephant. Man is sustained by well fields in “dry” stream beds which supply potable water to towns such as Walvis Bay and Swakopmund.

Marine

It is apparent that, in addition to steady-state and storm waves, a strong northerly littoral drift is instrumental in preventing the formation of a delta at the mouth of the Orange River. Instead, the great volumes of sediment, intermittently transported by the Orange and other rivers, are rapidly dispersed northwards, resulting in extensive lagoons and sand spits in places where, bathymetry and hydrodynamic conditions favor...
Figure 14. Satellite image (left) and interpretation (right) showing dune patterns in the southern part of the Great Sand Sea inland from Hottentot Bay.
Figure 15. Satellite image and interpretation showing dune patterns in the vicinity of Sossus Vlei (Satellite Image after McKee et al., 1977.)
DISCUSSION

The present study suggests that future research should be concentrated on the theme of process interplay. It is apparent that within this region, in particular, it is impossible to address the larger geomorphological issues, without analyzing the dynamic interaction of complex factors that influence their existence.

For example, the question of whether the Kuiseb River will continue to form the boundary of the Great Sand Sea (Figure 5), cannot be answered by merely measuring the rate of northerly dune migration. Rather, this must be studied in conjunction with the hydrologic characteristics of the river, and the influence of marine processes in choking off the mouth of the river. And even within this dynamic system, care must be taken to ensure that all relevant variables are considered. For instance, on the further question of whether an assessment of the rate of dune migration alone is sufficient to evaluate the contribution of wind to the model, the answer is clearly no. This is because the topographic influence of the stream bed tends to funnel winds parallel to the river alignment, thus helping to remove invading sand.

Similarly, in evaluating hydrologic controls, not only must the potential for sand removal by intermittent floods be examined, but also the possibility that the river, under sustained pressure from northerly migrating dunes, may slowly shift its course to the north, thus maintaining its integrity.

Thus if running water alone was responsible for maintaining an open stream channel, the Kuiseb River would, in all probability, long since have been truncated by the Sand Sea. Not only does the river exist for most of the time as a dry "omuramba," but rates of dune movement tend to be relatively rapid. For example, even south of the Great Sand Sea, where the sand supply is relatively sparse, the old (1910) mining town of Kolmanskop has been invaded by sand dunes (Figure 17). SEELY and SANDELOWSKY 1974 note a rate of movement of 7 m per year, for a small dune near the Kuiseb River.

Other rivers have been invaded and completely cut off by dunes. Interpretation of the satellite image shown in Figure 5, for example, suggests that the Tsondab River, presently separated from the ocean by an 80 km barrier of sand dunes, at one time entered the Atlantic at a point some 30 km south of Sandwich Bay. Sossus Vlei represents a similar case of a river invaded by dunes.

This evidence of past river truncation suggests...
that the Kuiseb River may be in a critical state, and that any man-induced changes, such as the construction of a dam on the river, might have serious consequences. Large dunes (Figure 18) already block the mouth of the Kuiseb River.

It is suggested that the type of broad-based geomorphological approach under discussion may contribute, also, to the solution of other problems. In the search for diamonds, for example, there is strong circumstantial evidence to support the hypothesis that both coastal and offshore diamonds are ultimately derived from one or more inland sources. This includes: (1) the fact that deep-water prospecting indicated that marine diamonds were confined to near-shore sediments, (2) observations by DE BEERS (1976) which show that the distribution modes of diamond size and concentration along the coast reflect not only a long transport path under the influence of littoral drift, but provide evidence also of concentration near the mouths of larger rivers, and (3) a long history of diamond concentration along the courses of major streams.

One might expect coastal and/or offshore diamonds, therefore, to be concentrated near the mouth of the truncated Tsondab River. Sand-penetrating radar imagery may be used to locate the mouths of other old rivers such as the TsauChab.

It is of greater significance, however, that in the model postulated by DE BEERS (1976) part of the diamond transportation cycle consisted of “accumulation as a widespread deflation residuum on one or more of the several continental erosion bevels developed in the hinterland.” According to this

CONCLUSIONS

If the DE BEERS (1976) hypothesis of “diamonds scattered over the continental erosion surface” is correct, then follow-up research should be concentrated not only on the further delineation of coastal terraces, but also on the broader regional aspects of geomorphological process interplay that characterize the cycles associated with pedimentation. In this context, the inland (Pre-A, A, B and C) terraces should be studied further.

In a more general sense, an attempt is made to show that controls on the geomorphology of the coastal desert are highly complex, and in a very delicate state of balance. The survival of this desert paradise and the unique, but highly fragile ecology that has adapted to it, is dependent on maintaining this state of balance. This area, which has taken millions of years to evolve as one of the oldest and most diverse desert environments in the world, could be irreversibly changed within a relatively short space of time by the activities of man (FAIRBRIDGE, 1976).

The authors support the expansion of both conservation areas and research projects that will help to preserve the Namib. Mining activities, which provide the basis of the Namibian economy, must also be permitted to expand. However, it is strongly recommended that the environmental impacts of all potential major developments (e.g. dams, harbors
accurately be cared for prior to construction. In this context an attempt is made to show that in the area of geology, reliable predictions can be given only by a systematic evaluation (e.g. Watson, 1984) of the interacting influence of a large number of contributing variables.

Finally we concur with Wagner (1927) that the Namib is "entitled to be regarded as one of the most remarkable stretches of coast-line in the world."

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